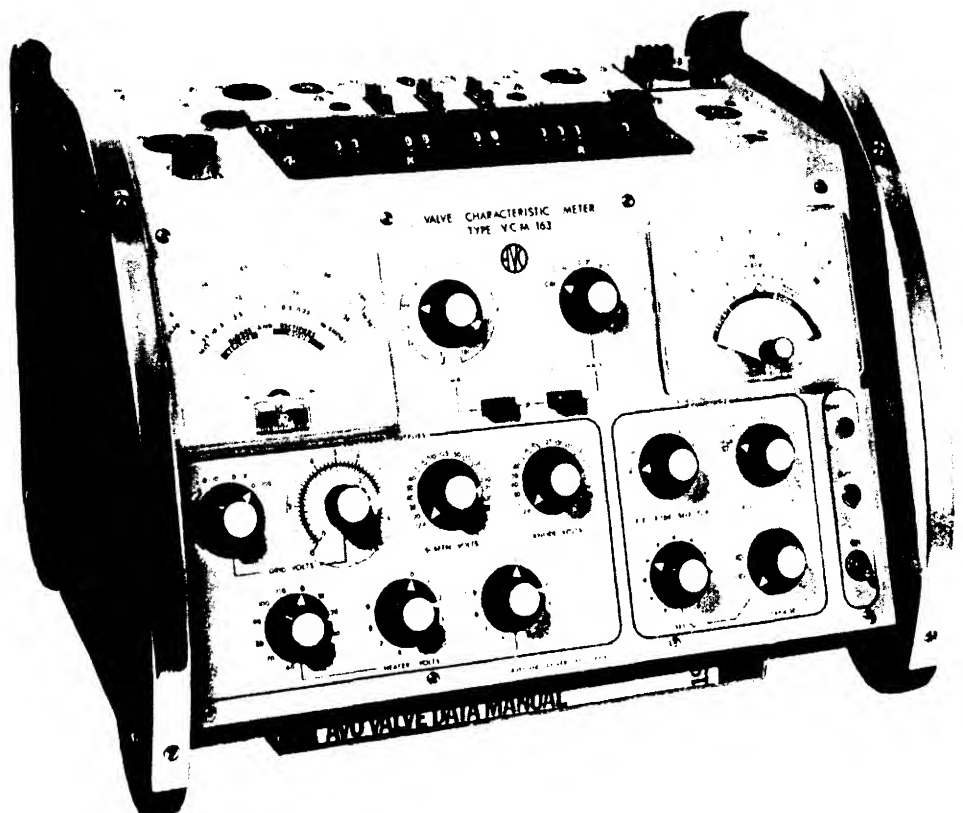




Service Manual

Type V.C.M. 163 Valve Characteristic Meter



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Service Manual

Type V.C.M. 163 Valve Characteristic Meter

These instructions have been written to provide a general guide to the servicing of the Valve Characteristic Meter Type VCM 163.

No attempt should be made to service this Valve Characteristic Meter Type VCM 163 unless the full range of recommended test equipment (see Page 1) is available.

VALVE CHARACTERISTIC METER TYPE VCM 163

SERVICE MANUAL

TEST EQUIPMENT REQUIRED

- (a) Electronic Avometer Type EA 113 (or equivalent)
- (b) Model 8 Avometers
- (c) Valve E55L (standardised for mutual conductance at 16mA anode current)
- (d) Resistors various, $1M\Omega \pm 5\%$, $1k\Omega$ 3W variable, $3.9k\Omega \pm 5\%$ 4.5W,
 $960\Omega \pm 5\%$ with a rating of greater than 30W,
 $150\Omega \pm 1\%$ 5W
- (e) 500V Megger
- (f) Valve 12AT7 and Rectifier Valve U52
- (g) Silicon Diode DD058

GENERAL NOTES

Care should be exercised when servicing due to the presence of up to 480V rms within the interior of the instrument.

All measurements and tolerances stated do not include those of the testing instrument, and where necessary, these should be ascertained, in order that they may be taken into consideration during calibration procedure. It is recommended that the specified instruments are employed.

If at any time it is necessary to displace wiring within the instrument, great care must be taken to ensure that it is replaced in the original position.

TO CHECK THE ACCURACY USING STANDARDISED VALVES

Where the accuracy of the instrument is in doubt, standardised valves may be used to check the instrument. For this, an I_a/V_g curve must be plotted at recommended V_a (See Valve Data Book). From the curve obtain the Mutual Conductance at a point (I_a/V_g) preferably given by the Valve Data Book, if it is on the linear portion of the characteristic.

$$\text{Mutual Conductance} = \frac{I_a}{V_g}$$

Adequately smoothed dc supplies should be used and Model 8 Avometers to monitor V_a , I_a and V_g . A valve to be standardised must be aged for at least 24 hours and once the valve is standardised it must be labelled and dated.

RAPID PERFORMANCE CHECKS

- (a) Ensure that the mains switch is off.
- (b) Ascertain the voltage of the mains supply and set the MAINS VOLTAGE SELECTOR to the value nearest to that of the mains supply. Access to the VOLTAGE SELECTOR PANEL can be gained by removal of the left-hand side panel, which exposes a coarse voltage selector marked 110, 120, 200, 210, 220, 230 and 240V. The fuse should be inserted in the position which is marked with the nearest value to the supply voltage available.
- (c) Connect the mains lead of the instrument to the mains power supply. Set the MAINS switch on the panel to its 'on' position and observe that the red panel indicator lamp is illuminated.
- (d) Set the CIRCUIT SELECTOR switch to the position CHECK (C) and the LEAKAGE switch to \sim . The mA meter pointer should now move across the scale and come to rest near the black region of the insulation scale thus denoting zero ohms.
- (e) Rotate the SET \sim control until the meter pointer is as near as possible to the red line marked \sim in the middle of this black scale marking.
- (f) If the initial setting of the MAINS VOLTAGE SELECTOR is correct, it will be possible for the meter pointer to be moved to either side of the red line using the SET \sim control.
- (g) If this is not possible and rotation of the SET \sim control does not enable the pointer to reach the \sim mark from either direction, then the initial mains setting should be moved to the next appropriate tapping. If the pointer is too far right of the \sim mark, move to the next higher tapping and, in a similar manner, it should be moved to the next lower tapping if the pointer is too far to the left of the \sim mark.
- (h) Once the mains voltage setting has been correctly set, provided extensive mains fluctuations do not occur, test voltages should be automatically correct throughout the instrument.
- (j) Using standardised valves check that for a given anode current the bias is within $\pm 5\%$ of range value $+0.25V$ and g_m is within $\pm 5\%$ f.s.d. of standardised value.
- (k) Check the 'Gas' position of the CIRCUIT SELECTOR switch. Insert a $1M\Omega$ resistance between g'_1 and C. Set VALVE PIN SELECTOR switches 1 and 2 to c and g'_1 respectively and tap pins 1 and 2 on SP14S.
- (m) Adjust grid volts for half full scale deflection on mA meter. The grid volts should be between 45 and 55.
- (n) Disconnect the resistance and switch off.

SIMPLE FAULTS

To facilitate servicing or calibration of the instrument, it is necessary to remove the back and side plates from the instrument case. This is accomplished by the removal of four instrument headed screws from the side plates and six round headed screws from the back plate. The valve panel is then also readily accessible.

<u>Symptoms</u>	<u>Possible Fault</u>	<u>Action</u>
No red panel lamp indication	No mains input Indicator bulb burnt out	Check mains connector Replace red indicator bulb
No red panel lamp indication or meter deflection	Fuse blown	Check MAINS VOLTAGE SELECTOR. Replace fuse
No indication of meter current	No anode volts at valve pin	Check that the anode link is tight and making firm contact
No indication of meter current and protective relay operates when testing tetrodes or pentodes	No anode volts at valve pin (screen volts present)	Check that anode link is tight and making firm contact

PROTECTIVE RELAY OPERATION

- (a) Connect a $960\Omega \pm 5\%$ resistor with a rating of 30W between anode and cathode circuits.
- (b) Set the Anode Volts to 12.6, the mA switch to Ia 100 and CIRCUIT SELECTOR to 'Test'
- (c) Connect the instrument to the mains supply (See Rapid Performance Checks) and switch on.
- (d) Increase the Anode Volts step by step until the cut-out operates. The voltage at which this occurs must lie within the limits 175V to 350V inclusive.
- (e) Set the Anode Volts to 150 and switch instrument on and off several times. The cut-out must not operate.
- (f) Repeat at 350V. The cut-out must operate every time.

Should the overload relay operate during testing (indicated by the lighting of the blue overload lamp on the front panel) switch off and check for incorrect setting of the SELECTOR switch or electrode voltages. If these are correct, but the relay continues to operate when the instrument is switched on again, the valve is probably soft and the test should proceed no further. Switch off and remove the valve under test. When switched on again, the instrument should function normally.

SERVICING THE VALVEHOLDER PANEL

The valveholder panel is connected electrically to the control panel by means of a 12-way tagboard. The wiring of the valveholders on the panel is in the form of thirteen separate loops, all pins numbered '1' comprising a loop and linking in roller '1' of the ROLLER SELECTOR switch, and pins numbered '2' forming a second loop and linking to roller '2', and so on.

This form of connection is used for all other pins, all thirteen circuits being approximately equal in length and following a similar path around the panel. These loops are loaded with ferroxcube beads which sufficiently damp the loop to prevent the valve breaking into parasitic oscillation. Ferroxcube beads are also used on leads feeding the ROLLER SELECTOR switch as a further protection against oscillation.

Where it is necessary to replace valveholders, those fitted to the panel with nuts and bolts are easily removable. When removing rivetted valveholders care should be taken to ensure that rivets are drilled out from the underside of the panel. All wire must be replaced in its original position.

VOLTAGE CHECKS WITH NO VALVE UNDER TEST

Connect the instrument via a variac to the mains input. The output from the variac should be monitored with an ac voltmeter which is accurate to $\pm 0.5\%$ at 240V. Adjust the variac until the voltmeter reads 240V. The mains fuse should be inserted in the VOLTAGE SELECTOR panel for 240V operation. Ensure that the instrument is switched off whilst making these adjustments.

Set switches as follows: Set \sim at mid-point, Leakage at \sim , CIRCUIT SELECTOR at CHECK (H) or CHECK (C).

Anode and Screen Voltages

- (a) Set VALVE PIN SELECTOR switches TC1 and TC2 to 1 and 8 respectively
- (b) Connect an Avometer Model 8 (set to measure dc volts) across the top cap sockets.
- (c) Set the mA switch to $I_a = 100$ and CIRCUIT SELECTOR switch to Test.
- (d) Vary the Anode Volts from 12.6 to 400 and observe the following limits:

NOMINAL	ACTUAL	LIMITS
12.6	7.24	6.7 - 7.2
20	11	10.3 - 11.1
30	16.05	15.2 - 16.3
40	21.1	20.2 - 21.4
50	26.2	25.1 - 26.7
60	31.25	30.1 - 31.9
75	38.8	37.5 - 39.7
90	46.4	44.7 - 47.5
100	51.5	49.7 - 52.7
125	64.2	62.2 - 65.7
150	77	74.7 - 78.7
175	89.65	87.2 - 91.7
200	102.3	100 - 105
225	115	112 - 118
250	128	125 - 131
275	140.5	137 - 144
300	153.3	150 - 157
350	178.9	175 - 183
400	204	200 - 208

- (e) Set TC2 to 7 and observe that the above readings are repeated as the Screen Volts are varied.

Heater Voltages

- (a) Set the VALVE PIN SELECTOR switches TC1 and TC2 to 2 and 3 respectively.
- (b) Connect a Model 8 Avometer set for ac voltage across TC1 and TC2.

(c) Set the CIRCUIT SELECTOR to CHECK (H) and measure Heater Volts.

NOMINAL	ACTUAL	NOMINAL	ACTUAL
0.1	0.102	40	40.8
0.2	0.204	50	51
0.3	0.306	60	61.2
0.4	0.41	70	71.4
0.5	0.51	80	81.6
10	10.2	90	91.8
20	20.4	100	102
30	30.6	110	112.2

Limits are not given for this test, the purpose of the test is to ensure that the correct tapings of the transformer are connected to their appropriate switch positions.

(d) Switch off and remove the meter.

SETTING-UP PROCEDURE

Note: The Multimeter used in the following calibration procedure should be standardised at the appropriate voltages before making any adjustment as mentioned in the following paragraphs.

- (a) Set all pre-set controls at approximately mid-point (RV1, RV2 and RV3 on the potentiometer board and RV1 and RV2 on the oscillator board). If the instrument has been previously calibrated and no replacement of relevant components has been necessary, do not adjust the potentiometers unless it is obvious that adjustment is required.
- (b) Check mechanical zero adjustment on panel mounted meters and set zero if required on both meters.
- (c) Set the VOLTAGE SELECTOR to 240 volts and check that the mains wires are connected to their appropriate tags (Red - line, Black - N, Green - E.)
- (d) Carry out a continuity test with the Model 8 ensuring that earth is connected to the frame of the instrument.
- (e) Using the 500V Megger, test the insulation between:
 - (i) *zero line and mains wire (Red - line, Black - neutral)
 - (ii) zero line and the frame of the instrument.

* a convenient point on the zero line is the junction of LP1 and LP2.

With the instrument supply switch at 'on' the insulation should be greater than 100M Ω).

- (f) Feed the mains input from a variac (output from variac to be monitored with an ac voltmeter which is accurate to $\pm 0.5\%$ at 240 volts). Adjust variac until voltmeter reads 240V.

- (g) With the instrument switched on, set switches as follows:
 SET \sim at mid-point, LEAKAGE at \sim , CIRCUIT SELECTOR at CHECK (H) or CHECK (C).
- (h) Set the mA meter to the red line marked \sim by adjusting RV3 and ensuring that the ac voltmeter reads exactly 240V at this point.
- (j) Rotate the SET \sim switch from full anti-clockwise position to full clockwise position and check that an increase is indicated on the mA meter for each position of the switch.
- (k) Connect a dc voltmeter between zero line and the junction of RV2 and R21. The accuracy of the voltmeter must be $\pm 0.5\%$ at 52V dc and the sensitivity 20,000 Ω /V or higher.
- (m) Set the CIRCUIT SELECTOR switch to Test and adjust RV2 until the voltmeter reads 52V dc, again ensuring that the mains is exactly 240V.
- (n) Connect a dc voltmeter (Model 8) across zero line and the slider of RV4 (mounted on the front panel). Set the Grid volts control such that when the cursor is at zero the voltmeter reads zero and there is an indication on the meter immediately after the cursor passes the zero position.
- (p) Replace the Model 8 by an electronic multimeter and with the cursor set to 5, set the Grid volts switch to each position in turn.
- (q) The voltage should read 0.78, 2.6, 7.8 and 26 volts $\pm 3\%$ as the Grid Volts switch is set to 0-3, 0-10, 0-30 and 0-100 respectively.
- (r) Check that the oscillator board is connected to the correct H.T. transformerappings, i.e. oscillator board tags 1 and 2 are connected to transformer tags 6 and 8. Check that the voltage across tags 1 and 2 is approximately 24V r.m.s. and the voltage across C7 (oscillator board) is approximately 12V dc $\pm 5\%$.
- (s) Connect the electronic multimeter across the red and brown (earthy) sockets on the amplifier board. Set the electronic multimeter to the 30mV ac range (or as appropriate) and adjust RV1 on the oscillator board until the multimeter reads 15mV. This setting is only correct when the ambient temperature is between 18° and 22°C.
- (t) Set the mA/V switch to Cal and RV1 on the potentiometer board to mid-range. (Do not adjust RV1 if it has not been replaced).
- (u) Adjust RV2 (oscillator board) until the mA/V meter pointer is on the red line marked Cal. Final fine adjustment can be made by adjusting RV1 on the potentiometer board.
- (v) Connect a sub-standard dc ammeter in series with a 1k Ω variable 3W resistor and 3.9k $\Omega \pm 5\%$, 4.5W fixed resistor. Connect the whole arrangement across anode and cathode links on the valve panel.

- (w) Set the mA switch to Ia, 3mA, the Anode Volts to 12.6 and the CIRCUIT SELECTOR switch to Test. Adjust the variable resistor to set the mA meter to full scale. The sub-standard meter should read $1.5\text{mA} \pm 2.5\%$. Repeat this test for the following switch settings:

<u>Ia</u>	<u>Va</u>	<u>Sub-standard meter reading</u>
10	40	$5\text{mA} \pm 2.5\%$
*30	12.6	$15\text{mA} \pm 2.5\%$
*100	50	$50\text{mA} \pm 4\%$

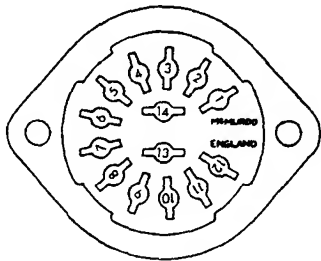
*For these settings short the 3.9kΩ resistor.

FINAL TEST PROCEDURE

When all repairs have been carried out and the instrument is re-assembled, carry out the following final test detail.

- (a) Apply a 500V Megger test between the mains input and frame.
- (b) Apply 240V via a variac to the instrument and adjust the meter pointer to the \sim mark on the scaleplate. (For full details see Rapid Performance Checks (d) to (g).
- (c) Set the VALVE PIN SELECTOR switch to 133 456 789 XYZ0
- (d) Set the CIRCUIT SELECTOR switch to CHECK (C)
- (e) Using the SP14S valveholder on the valve panel, connect a $1\text{M}\Omega \pm 5\%$ resistor between pin 1 and the pins listed below, as the LEAKAGE switch is set to the positions shown. For each setting the mA meter should read $1\text{M}\Omega \pm 10\%$. For convenience, the pin numbering of the SP14S valveholder is given in the diagram.

<u>Pins</u>	<u>Leakage switch setting</u>
2	h (C)
3	c (C)
4	g'_1
5	g''_1
6	g'''_1
7	g_2
8	a
9	a'_d
10	a''_d
11	a'''_d
12	a''''_d



- (f) Set the CIRCUIT SELECTOR switch to CHECK (H) and test as in (e) for one or two positions.
- (g) Set the CIRCUIT SELECTOR switch to C/h INS and connect the $1M\Omega$ resistor between cathode and heater. The meter should again read $1M\Omega \pm 10\%$.
- (h) Set the Anode Volts to 12.6, the mA switch to Ia 100 and CIRCUIT SELECTOR to Test.
- (j) Connect a resistor of $960\Omega \pm 5\%$ having a rating of much greater than 30W between anode and cathode circuits.
- (k) Increase the Anode volts step by step until the cut-out operates. The voltage at which this occurs must lie within the limits of 175V to 350V inclusive.
- (m) Set the Anode volts to 150 and switch instrument on and off several times. The cut-out must not operate. Repeat at 350 volts. The cut-out must operate every time.
- (n) Set VALVE PIN SELECTOR switch to 817 231 141, Anode and Screen volts to 125V, Grid volts to 3V and Heater volts to 6.3V. Set the ELECTRODE SELECTOR switch to a'. Insert an E55L standardised valve and obtain the values applicable to the valve as standardised. Ensure that the valve does not oscillate.
- (p) Repeat (n) for the following settings:

Valve Pin Selector

817 231 151
817 231 161

Electrode Selector

a"
a'''

- (q) Set the CIRCUIT SELECTOR switch to Gas position and observe that both meters read zero. (Half a division on the top scale is permitted). Both meters must also read zero when the mA/V push-button is depressed.
- (r) Using standardised valves* check that for a given anode current the bias is within $\pm 5\%$ of range value + 0.25V and that g_m is within $\pm 5\%$ f.s.d. of standardised value.

*One valve for each range and a directly heated valve must be tested.

- (s) Check the Gas position of the CIRCUIT SELECTOR switch. Insert a one megohm resistor between g'_1 and C, set VALVE PIN SELECTOR switches 1 and 2 to c and g'_1 respectively and tap pins 1 and 2 on SP14S. Adjust Grid volts for half full scale deflection on mA meter. The voltage across the $1M\Omega$ resistor should be between 45 and 55V.
- (t) Using the Avo Valve Data Manual set up the instrument to test a valve 12AT7. Switch the CIRCUIT SELECTOR to Gas. There should be no reverse deflection of the pointer for any bias more negative than -3V.

- (u) Connect a 150Ω resistor $\pm 1\%$, 5W in series with a silicon diode DD058. Use this as a standard rectifier to test the D/R ranges. Set the VALVE PIN SELECTOR switches 1 and 2 to c and a'_d respectively, and tap pins 1 and 2 on SP14S. The readings should be as listed below:

<u>D/R Range</u>	<u>Reading on 100 scale</u>
180mA	67 - 82
120mA	70 - 85
60mA	75 - 90
30mA	80 - 95
15mA	85 - 95
5mA	87 - 97
1mA	95 - 103

- (v) Set up the instrument in accordance with the Avo Valve Data Manual to test a rectifier valve U52 using a valve which is known to be good. Set the ELECTRODE SELECTOR at a'_d and a''_d and check that the pointer lies near the centre of the 'Good' region, i.e. between 70 and 80 on the 0 - 100 scale.
- (w) Re-set the VALVE PIN SELECTOR switch to supply diode anodes a'''_d and a''''_d instead of a'_d and a''_d. (VALVE PIN SELECTOR SETTINGS 030 ZOY 020).
- Check as in (v) that the same readings are now obtained in the appropriate position of the ELECTRODE SELECTOR switch.
- (x) Switch off and remove all test instruments. Set the CIRCUIT SELECTOR and mA switches to Test and . respectively before transport.

SPARE PARTS LISTS

Individual assemblies are illustrated in Figs. 2 to 9 incl. An associated Parts List is given for each assembly which details the description and relevant Part No. of the individual components.

An overall interior view of the instrument is given in Fig. 1 which indicates the location of the individual assemblies.

Following the illustrations additional Parts Lists in Circuit Reference No. order are given for each Circuit Diagram.

PROCEDURE FOR ORDERING SPARE PARTS

If you will follow the procedure set out below, delays will not occur due to the exchange of unnecessary correspondence:

- (i) Identify the spare part required from the appropriate Figure and ascertain the AVO Part No.
- (ii) When ordering state the Part No. and description of the item required, its location in the instrument and instrument serial number.

Overseas users should send their requirements to the AVO representative on their territory. If Parts are required in the United Kingdom application should be made direct to Avo Limited.

FIG. 1 CHASSIS ASSEMBLY

Item No.	Description	AVO Part No.
1	mA/Volt Switch Assembly S8 (see Fig. 6)	45190
2	Valve Panel Assembly (see Fig. 5)	45215
3	mA Switch Assembly S3 (see Fig. 7)	45189
4	Front Panel Assembly (see Fig. 2)	45193
5	Grid Volts Switch Assembly S10 (see Fig.8)	45188
6	Component Board Assembly (see Fig. 9)	45194
7	Amplifier Board Assembly (see Fig. 3)	45001
8	Oscillator & Power Unit Board Assembly (see Fig. 4)	45002
RV1	Potentiometer 500 Ω	27133-326
RV2	Potentiometer 1k Ω	27133-331
RV3	Potentiometer 2k Ω	27133-341
T1	H.T. Transformer Assembly	45185
T2	L.T. Transformer Assembly	45197
RL1	Relay	45211
C1-C4	Capacitors 1 μ F 400V	27538-318
D4	Diode DD058	28461-501
D5, D6	Diode IN2069	28462-696

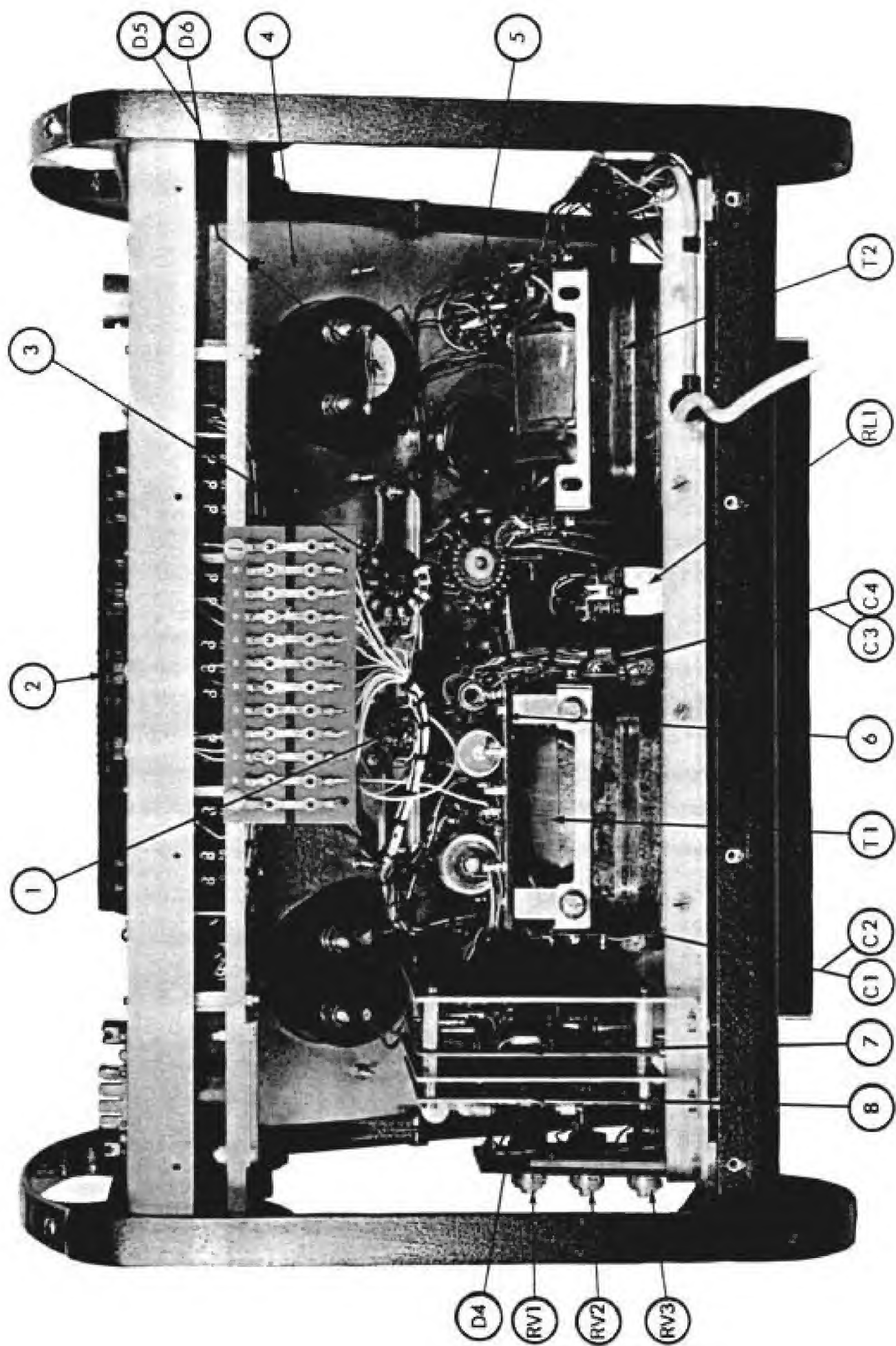


Fig1. Chassis Assembly

FIG. 2- FRONT PANEL ASSEMBLY 45193

Item No.	Description	Avo Part No.
1	Switch Circuit Selector S5	45187
2	Switch Electrode Selector S4	45828
6	Switch mA/V S8 (see Fig. 6)	45190
9	Switch mA S3 (see Fig. 7)	45189
12	Switch Grid Volts S10 (see Fig. 8)	45188
13	Switch Heater Volts S11	45818
14	Switch Heater Volts S12, S13	45825
15	Switch Screen & Anode Volts S1, S2	45803
20	Switch Set Cycles S14	45823
21	Switch Leakage S6	45816
22	Toggle Switch On/Off S15	25454-251
23	Indicator Lamp (Red) LP2	25517-233
24	Bulb 6.5V 0.35A	25514-679
25	Indicator Lamp (Blue) LP1	25517-235
26	Potentiometer Grid Volts RV4	27238-232
28	Front Panel	3286-619
30	Meter Assembly mA/V M1	45206
31	Meter Assembly mA M2	45191
33	Knob Assembly	45913
37	Push-button switch mA/V S7	45431
38	Push-button switch mA S9	45524
39	Knob Collet Black	23762-235
40	Knob Cap Grey	23762-884
41	Knob Skirt Black	23762-854
42	Resistor 2.4k \pm 1% (R33)	26232-382
43	Resistor 56k \pm 2% (R32)	26834-497

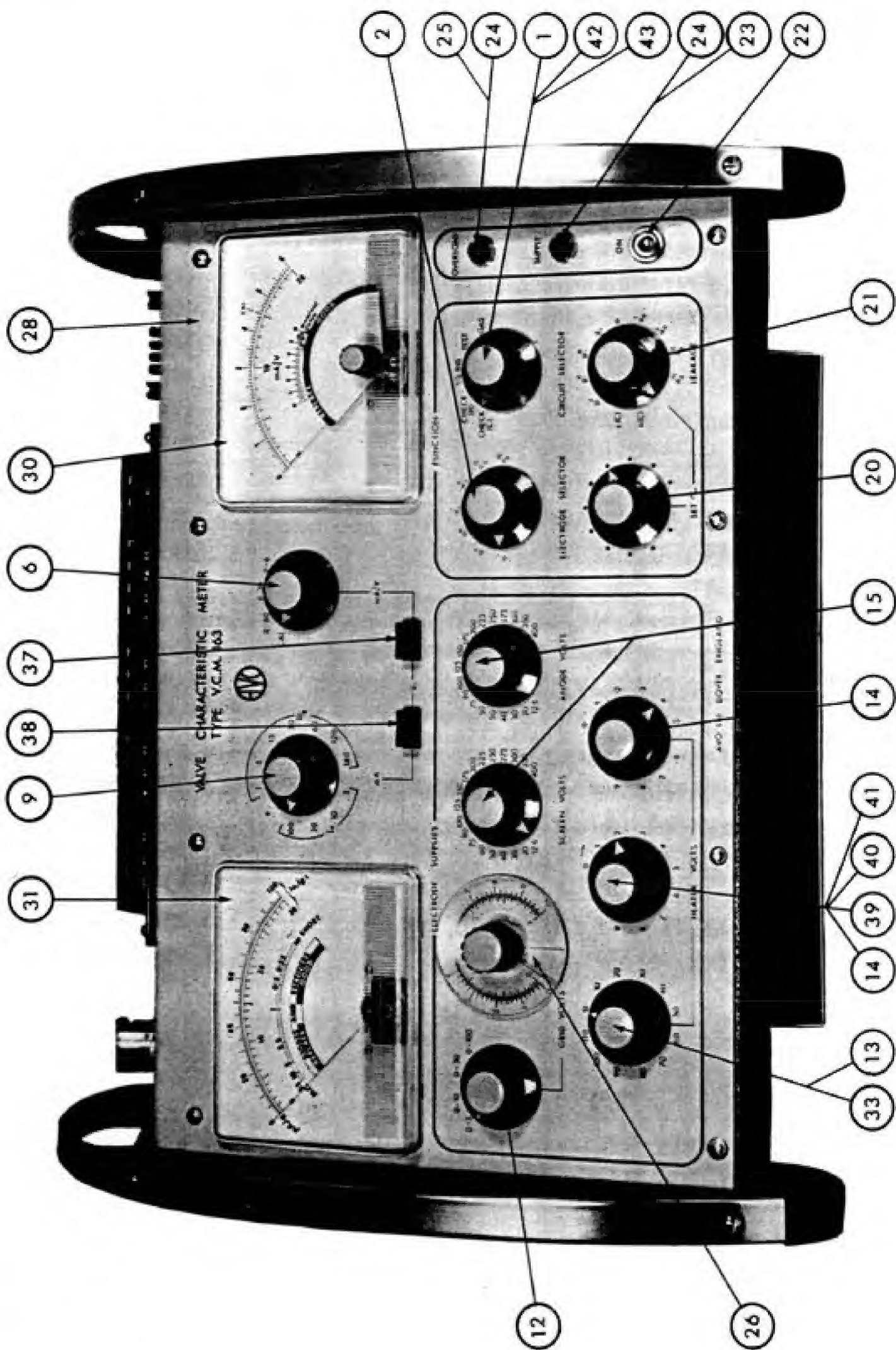


Fig 2. Front Panel Assembly 45193

FIG.3-AMPLIFIER BOARD ASSEMBLY 45001

Item No.	Description	Avo Part No.
1	Printed Circuit Board	3218-326
2	Transistors 2N2926 (VT1, 2 & 3)	28552-601
3	Resistor 9.1k \pm 2% (R2)	26834-478
4	Capacitor 0.01 μ F \pm 20% 160V dc (C4)	27532-125
5	Resistor 56k \pm 2% (R6)	26834-497
6	Resistor 10k \pm 2% (R5, R8)	26834-479
7	Resistor 20k \pm 2% (R7, R11)	26834-486
8	Capacitor 330pF \pm 20% 400V dc (C10)	27532-106
9	Resistor 3.3k \pm 2% (R9)	26834-467
10	Capacitor 10 μ F 15V dc (C3, 5 & 6)	27462-405
11	Resistor 82k \pm 2% (R10)	26834-501
12	Resistor 5.6k \pm 2% (R13)	26834-473
13	Resistor 22k \pm 2% (R12)	26834-487
14	Capacitor 50 μ F 15V dc (C7)	27462-413
15	Resistor 200 Ω \pm 1% (R14)	26232-356
16	Capacitor 0.47 μ F \pm 10% 160V dc (C8,C9)	27537-161
17	Diode IN 914 (D1, 2, 3 & 4)	28433-801
19	Printed Circuit Tags	25255-372
20	Capacitor 1 μ F \pm 2% 150V dc (C1)	27533-845
21	Resistor 10 Ω \pm 1% (R1)	26232-325
22	Transformer	45003
23	Capacitor 1990pF \pm 2% 125V dc (C2)	27522-133
24	Resistor 15k \pm 1% (R3)	26232-401
25	Resistor 30k \pm 1% (R4)	26232-408

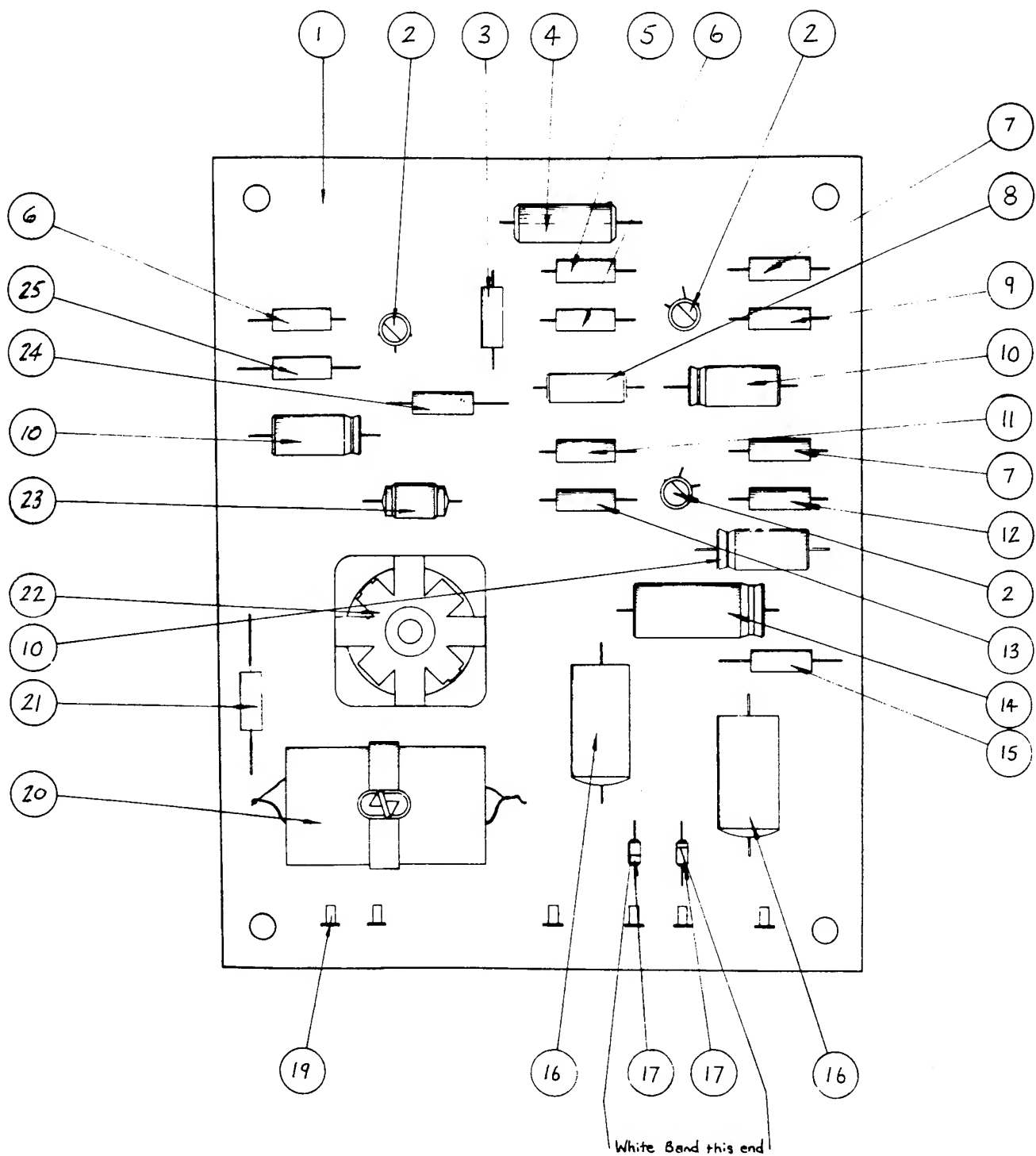


Fig3. Amplifier Board Assembly 45001

FIG.4- OSCILLATOR AND POWER UNIT BOARD ASSEMBLY 45002

Item No.	Description	Avo Part No.
1	Printed Circuit Board	3218-328
2	Thermistor Type R14 $10k \pm 20\%$ @ 20°C (TH2)	27284-318
3	Heat Sink	3565-615
4	Resistor $1k \pm 2\%$ (R9, R10)	26834-455
5	Capacitor $50\mu\text{F}$ 15V dc (C6)	27462-413
6	Thermistor Type A14 $10k \pm 20\%$ @ 20°C (TH1)	27284-330
7	Resistor $3k \pm 2\%$ (R14)	26834-466
8	Transistor 2N2926 (VT1, 2 & 3)	28552-601
9	Resistor $4.3k \pm 2\%$ (R15)	26834-470
10	Oscillator Output transformer (T1)	45004
11	Printed Circuit Tags	25255-372
12	Potentiometer $4.7k \pm 20\%$ (RV2)	27113-712
13	Resistor $30\Omega \pm 2\%$ (R18)	26834-418
14	Resistor $1.5k \pm 2\%$ (R11)	26834-459
15	Resistor $3.3k \pm 2\%$ (R8)	26834-467
16	Diode IS 921 (D1)	28461-824
17	Diode IZ125T5 (D2)	28475-281
18	Resistor $620\Omega \pm 2\%$ (R17)	26834-450
19	Resistor $36k \pm 2\%$ (R6)	26834-492
20	Capacitor $100\mu\text{F}$ 15V dc (C7)	27462-417
21	Capacitor $200\mu\text{F}$ 30V dc (C8)	27462-421
22	Resistor $8.2k \pm 2\%$ (R3)	26834-477
23	Resistor $20k \pm 1\%$ (R1)	26232-404
24	Resistor $6.8k \pm 1\%$ (R2)	26232-393
25	Capacitor $1990\text{pF} \pm 2\%$ 125V dc (C1, C2)	27522-133
26	Capacitor $10\mu\text{F}$ 15V dc (C3, 4 & 5)	27462-405
27	Resistor $5.1k \pm 1\%$ (R13)	26232-390
28	Resistor $1.2k \pm 2\%$ (R5)	26834-457
29	Resistor $2.4k \pm 2\%$ (R4)	26834-464
30	Potentiometer $1k \pm 20\%$ (RV1)	27113-749
31	Resistor $10k \pm 2\%$ (R7)	26834-479
32	Resistor $270\Omega \pm 2\%$ (R12)	26834-441
33	Resistor $10\Omega \pm 1\%$ (R19)	26232-325
34	Printed Circuit Socket	45052
35	Printed Circuit Socket	45085
40	Resistor $9.1k \pm 2\%$ (R16)	26834-478

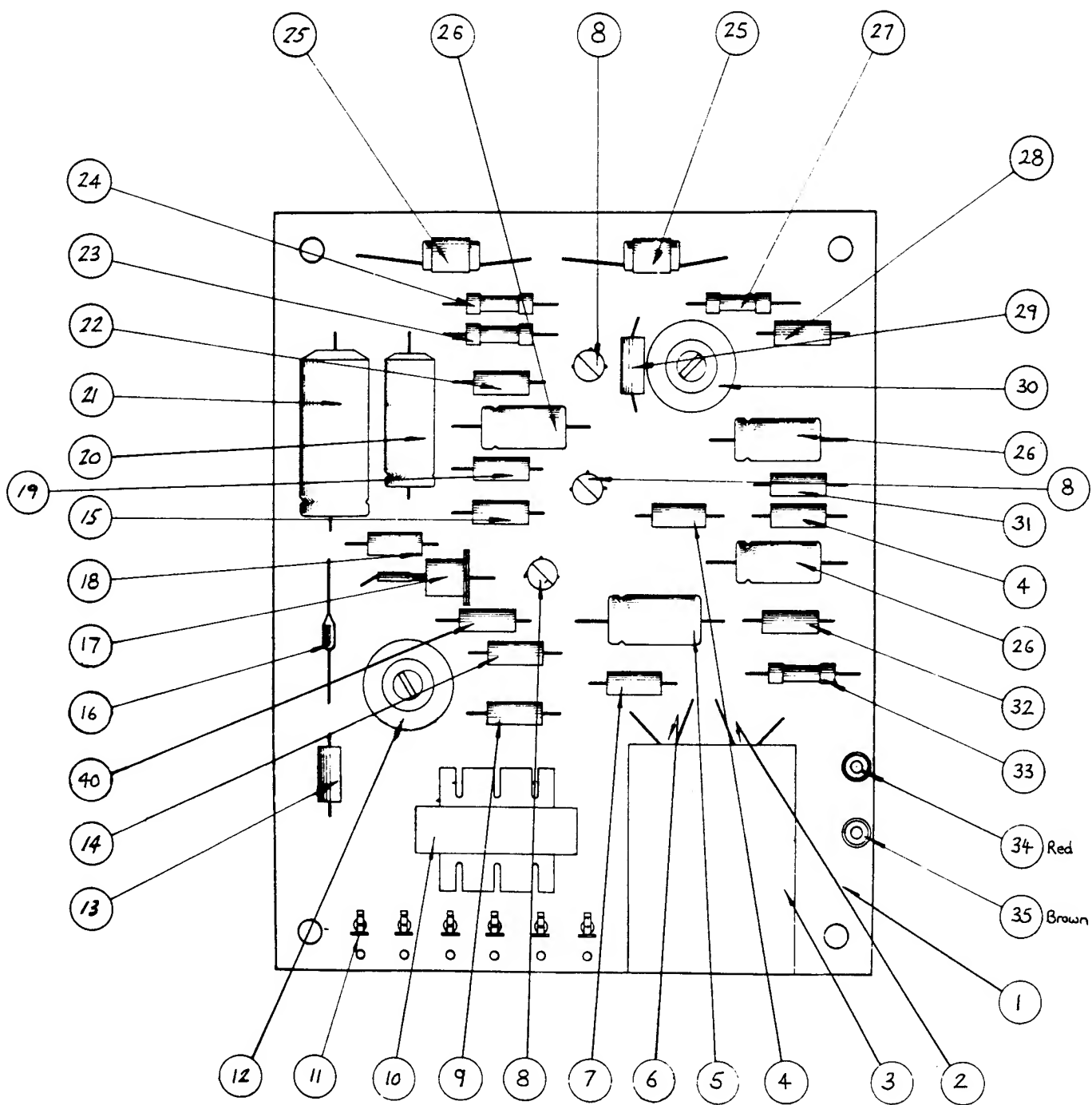


Fig 4. Oscillator and Power Unit Board Assembly 45002

FIG.5- VALVE PANEL ASSEMBLY 45215

Item No.	Description	Avo Part No.
1	Valve Panel	3267-506
2	Escutcheon	3876-424
4	Valve Pin Selector switch Assembly	45210
5	Valve Holder sub-assembly	45212
13	Holder Assembly	21199-A
14	Socket 14-way SP14S	25428-283
15	Valveholder B9G	28281-163
16	Valveholder B4/5 SP5E	28281-122
17	Valveholder B10B	28281-738
18	Valveholder B9A	28281-709
19	Valveholder B9D	28281-736
20	Valveholder I.0	28281-154
21	Valveholder Compactron	28281-757
22	Valveholder B8G	28281-676
23	Valveholder B7G	28281-632
24	Valveholder B8A	28281-663
42	Ferroxcube Bead (Not illustrated)	27888-321

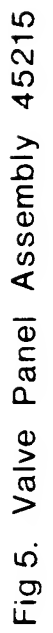


FIG.6- mA VOLT SWITCH ASSEMBLY 45190

Item No.	Description	Avo Part No.
1	Resistor $44.4\Omega \pm 1\%$ (R28)	26235-710
2	Resistor $88.9\Omega \pm 1\%$ (R29)	26235-717
3	Resistor $310\Omega \pm 1\%$ (R30)	26235-736
4	Resistor $1.3k\Omega \pm 2\%$ (R31)	26834-458
5	Capacitor $0.015\mu F +0, -20\%$ (C8)	27532-393
8	mA Volt switch	45821
9	Resistor $2.4k\Omega \pm 2\%$ (R35)	26834-464

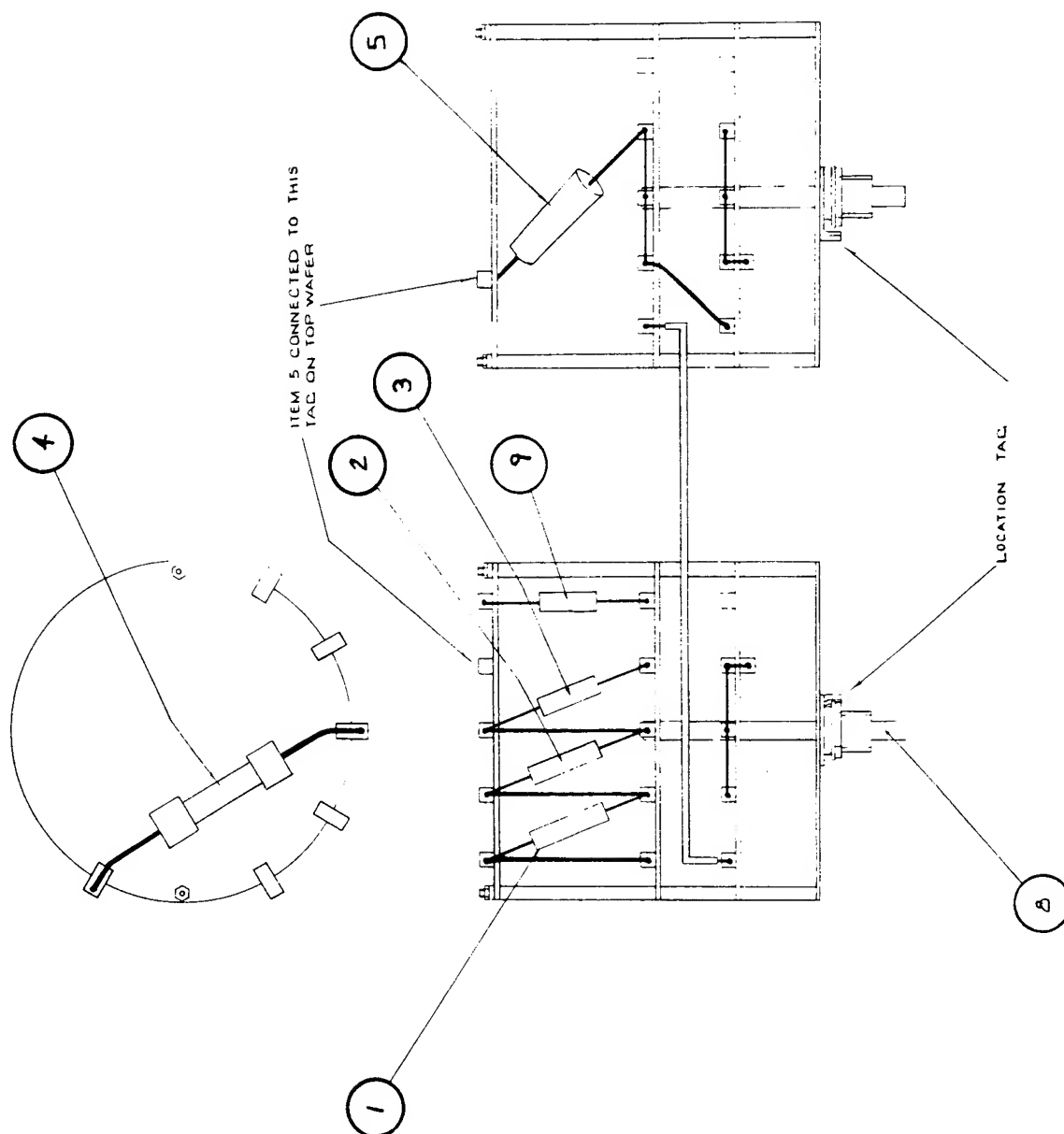


Fig 6. mA Volt Switch Assembly 45190

FIG.7- mA SWITCH ASSEMBLY 45189

Item No.	Description	Avo Part No.
1	mA Switch	45815
2	Resistor $3.4\text{M}\Omega \pm 1\%$ (R4)	26236-666
3	Resistor $82.8\Omega \pm 1\%$ (R14)	26444-232
4	Resistor $24.3\Omega \pm 1\%$ (R13)	26441-632
5	Resistor $8.02\Omega \pm 1\%$ (R12)	26437-372
6	Resistor $2.4\Omega \pm 0.05\Omega$ (R11)	26434-830
7	Resistor $16\text{k}\Omega \pm 1\%$ (R10)	26232-402
8	Resistor $281\text{k}\Omega \pm 1\%$ (R8)	26235-911
9	Resistor $680\text{k}\Omega \pm 1\%$ (R7)	26232-441
10	Resistor $1.3\text{M}\Omega \pm 1\%$ (R6)	26232-448
11	Resistor $2.27\text{M}\Omega \pm 1\%$ (R5)	26236-660
12	Resistor $1.1\text{k}\Omega \pm 1\%$ (R15)	26233-574
13	Resistor $4.3\text{k}\Omega \pm 1\%$ (R16)	26232-388
14	Resistor $22\text{k}\Omega \pm 1\%$ (R17)	26232-405
15	Resistor $91\text{k}\Omega \pm 1\%$ (R9)	26232-420

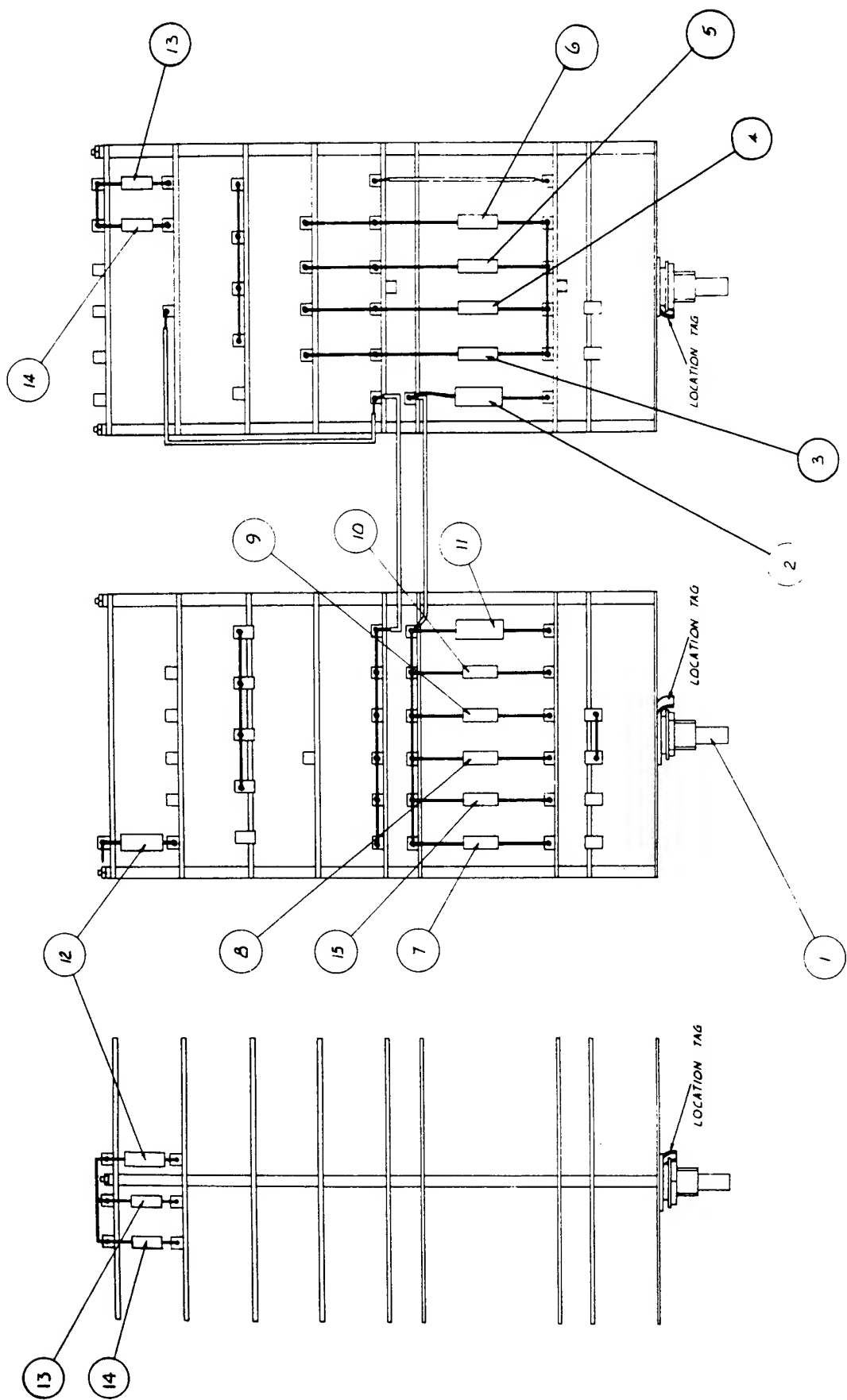


Fig 7. mA Switch Assembly 45189

FIG.8- GRID VOLTS SWITCH ASSEMBLY 45188

Item No.	Description	Avo Part No.
1	Grid Volts Switch	45817
2	Resistor $310\Omega \pm 1\%$ (R23)	26235-736
3	Resistor $1.11k\Omega \pm 1\%$ (R25)	26235-767
4	Resistor $4.29k\Omega \pm 1\%$ (R27)	26235-793
5	Resistor $9.7k\Omega \pm 1\%$ (R22)	26338-327
6	Resistor $9k\Omega \pm 1\%$ (R24)	26338-325
7	Resistor $7k\Omega \pm 1\%$ (R26)	26338-322
8	Resistor $2.2M\Omega \pm 1\%$ (R20, R21)	26233-653
9	Resistor $4.7k\Omega \pm 2\%$ (R19)	26834-471

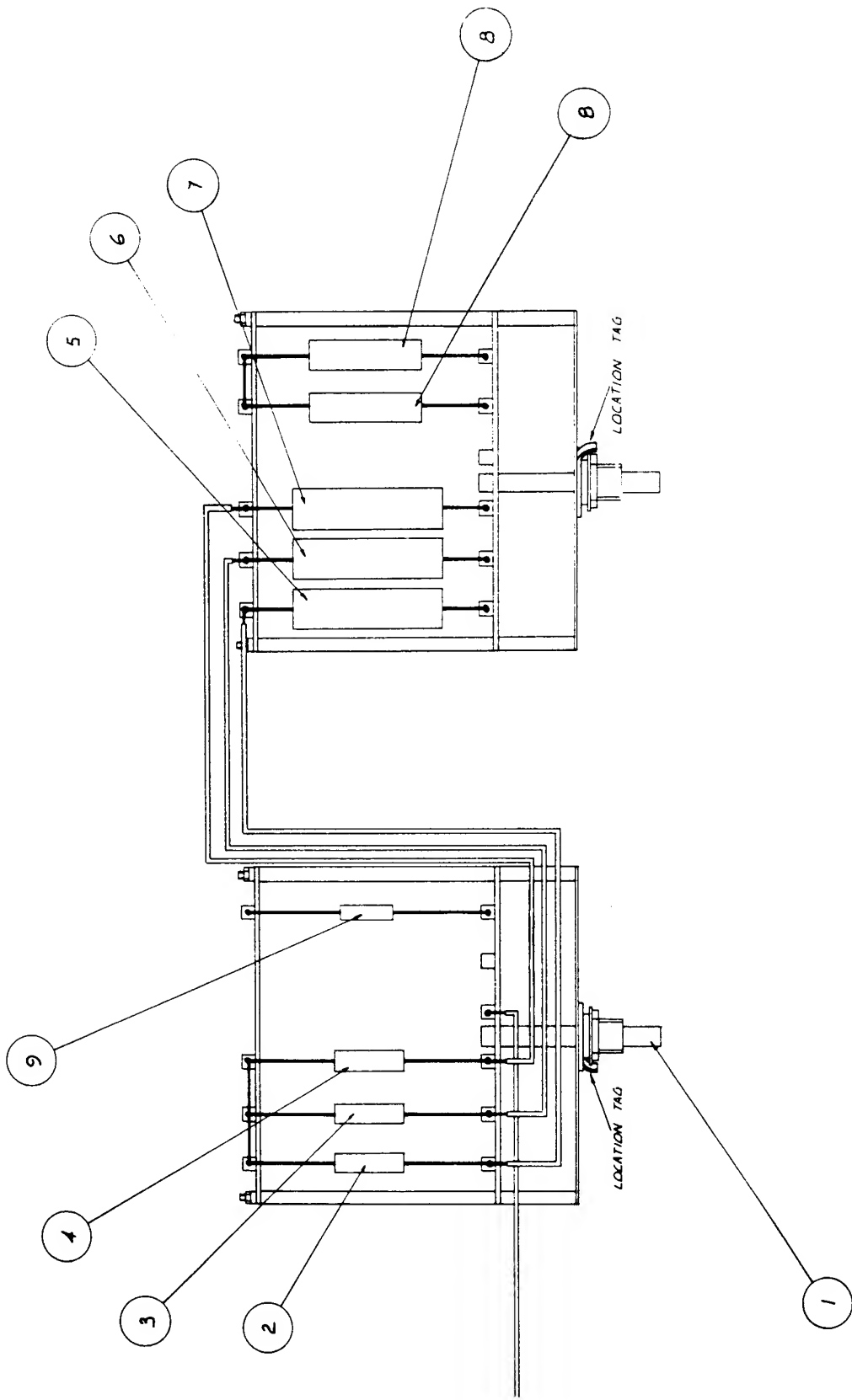


Fig 8. Grid Volts Switch Assembly 45188

FIG.9- COMPONENT BOARD ASSEMBLY 45194

Item No.	Description	Avo Part No.
1	Component Board	3836-452
2	Diode DD058 (D1, D2)	28468-501
3	Resistor $1.5\Omega \pm 5\%$ (R34)	26713-105
6	Resistor $100k\Omega \pm 20\%$ (R1, R2)	26136-221
7	Resistor $700\Omega \pm 2\%$ (R3)	26782-267
9	Capacitor $8\mu F$ 450V Electrolytic (C5)	27461-214
10	Capacitor $25\mu F$ 30V (C7)	27463-410
11	Capacitor $60\mu F$ 250V (C6)	27463-560
12	Resistor $0.68\Omega \pm 10\%$ (R18)	26711-253
13	Diode 10B1 (D3)	28461-841

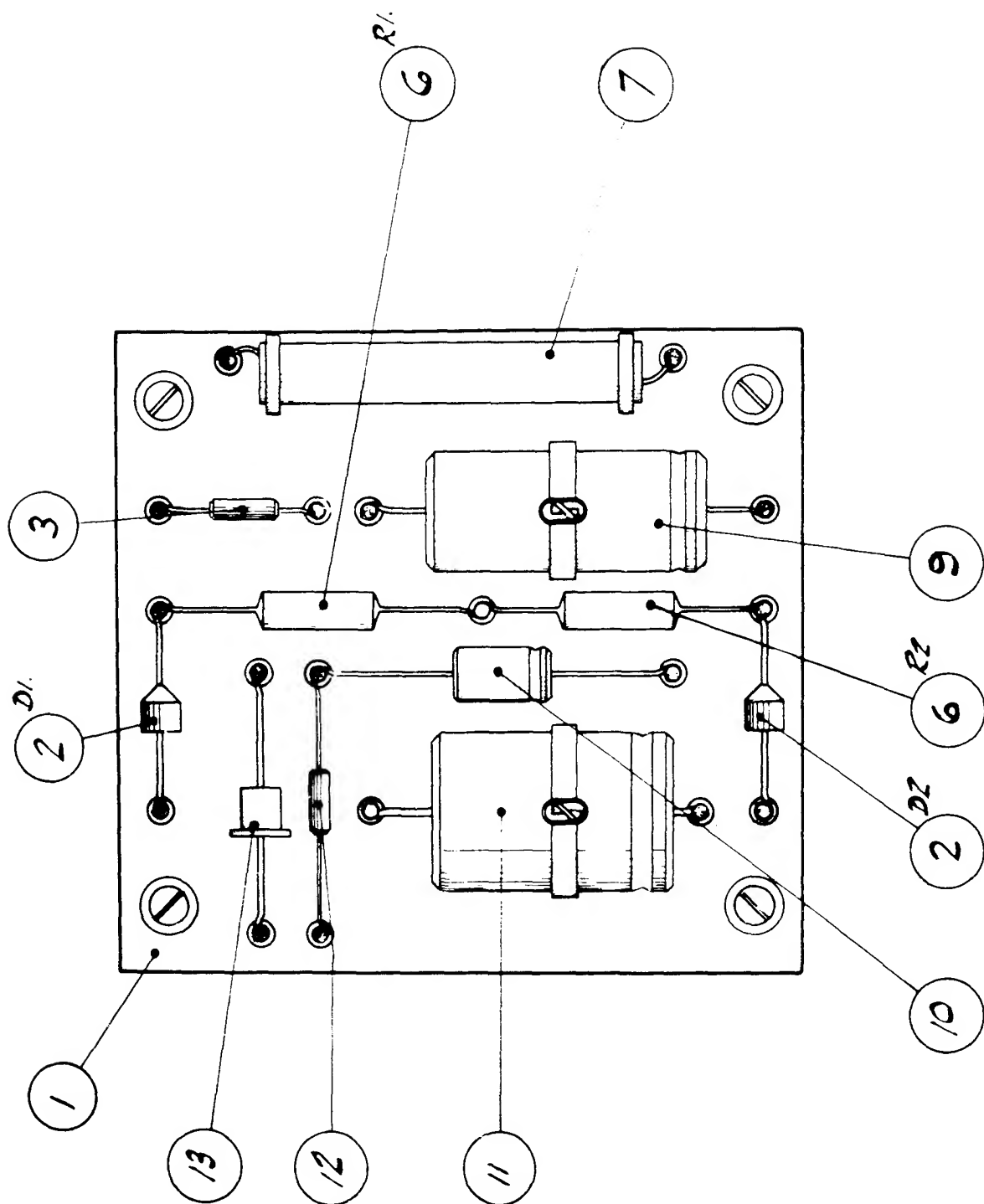


Fig 9. Component Board Assembly 45194

FIG. 10 - AMPLIFIER CIRCUIT DIAGRAM

Circuit Ref.	Assy Fig. No.	Item No.	Description	Qty	AVO Part No.
R1	3	21	Resistor $10\Omega \pm 1\%$	1	26232-325*
R2	3	3	Resistor $9.1k \pm 2\%$	1	26834-478*
R3	3	24	Resistor $15k \pm 1\%$	1	26232-401
R4	3	25	Resistor $30k \pm 1\%$	1	26232-408
R5	3	6	Resistor $10k \pm 2\%$	2	26834-479*
R6	3	5	Resistor $56k \pm 2\%$	1	26834-497
R7	3	7	Resistor $20k \pm 2\%$	2	26834-486
R8	3	6	Resistor $10k \pm 2\%$	2	26834-479*
R9	3	9	Resistor $3.3k \pm 2\%$	1	26834-467*
R10	3	11	Resistor $82k \pm 2\%$	1	26834-501
R11	3	7	Resistor $20k \pm 2\%$	2	26834-486
R12	3	13	Resistor $22k \pm 2\%$	1	26834-487
R13	3	12	Resistor $5.6k \pm 2\%$	1	26834-473
R14	3	15	Resistor $200\Omega \pm 1\%$	1	26232-356
C1	3	20	Cap. $1\mu F \pm 2\%$ 150V dc	1	27533-845
C2	3	23	Cap. $1990pF \pm 2\%$ 125V dc	1	27522-133*
C3	3	10	Cap. $10\mu F$ 15V dc	3	27462-405*
C4	3	4	Cap. $0.01\mu F \pm 20\%$ 160V dc	1	27532-125
C5	3	10	Cap. $10\mu F$ 15V dc	3	27462-405*
C6	3	10	Cap. $10\mu F$ 15V dc	3	27462-405*
C7	3	14	Cap. $50\mu F$ 15V dc	1	27462-413*
C8	3	16	Cap. $0.47\mu F \pm 10\%$ 160V dc)	2	27537-161
C9	3	16	Cap. $0.47\mu F \pm 10\%$ 160V dc)		
C10	3	8	Cap. $330pF \pm 20\%$ 400V dc	1	27532-106
VT1-VT3	3	2	Transistor 2N 926	3	28552-601*
D1-D4	3	17	Diode IN 914	4	28433-801
T1	3	22	Transformer	1	45003
-	3	1	Printed Circuit Board	1	3218-326
-	3	19	Printed Circuit Tags	6	25255-372*

* Additional quantities on Oscillator & Power Unit Board Fig. 4

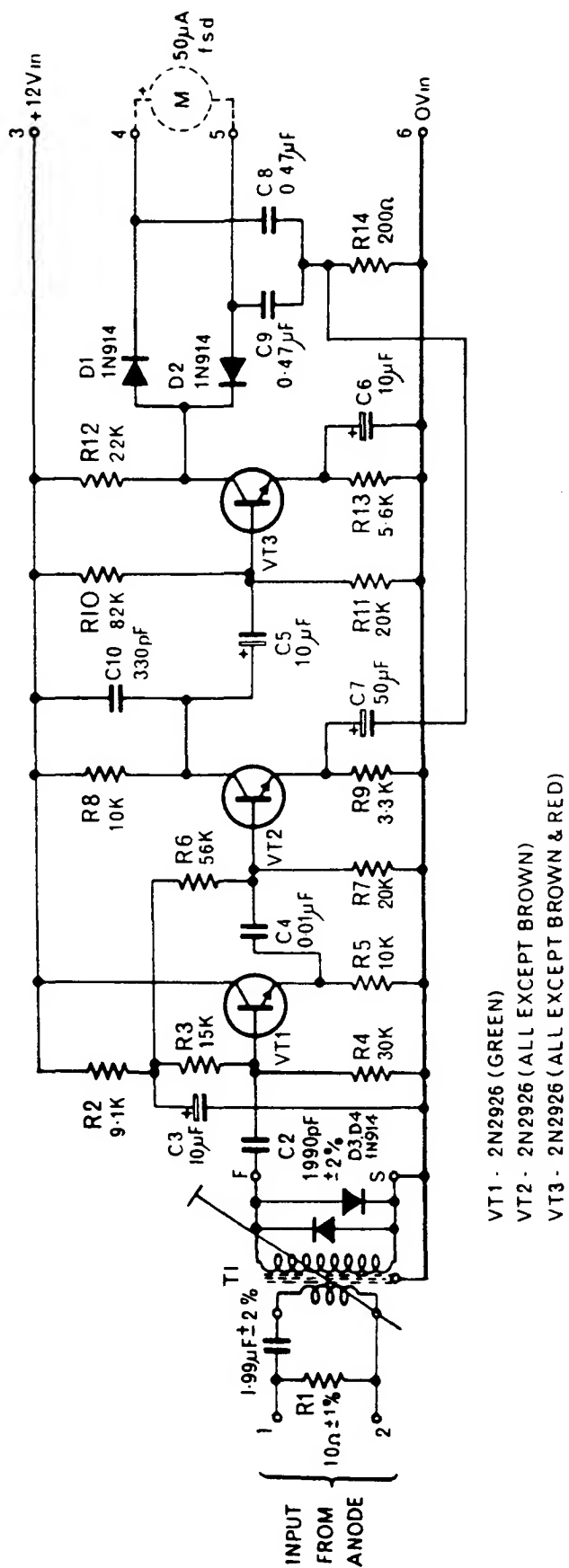


Fig 10. Amplifier Circuit Diagram

FIG. 11 - OSCILLATOR & POWER UNIT CIRCUIT DIAGRAM

Circuit Ref.	Assy Fig. No.	Item No.	Description	Qty	AVO Part No.
R1	4	23	Resistor 20k \pm 1%	1	26232-404
R2	4	24	Resistor 6.8k \pm 1%	1	26232-393
R3	4	22	Resistor 8.2k \pm 2%	1	26834-477
R4	4	29	Resistor 2.4k \pm 2%	1	26834-464
R5	4	28	Resistor 1.2k \pm 2%	1	26834-457
R6	4	19	Resistor 36k \pm 2%	1	26834-492
R7	4	31	Resistor 10k \pm 2%	1	26834-279*
R8	4	15	Resistor 3.3k \pm 2%	1	26834-467*
R9	4	4	Resistor 1k \pm 2%)	2	26834-455
R10	4	4	Resistor 1k \pm 2%)		
R11	4	14	Resistor 1.5k \pm 2%	1	26834-459
R12	4	32	Resistor 270 Ω \pm 2%	1	26834-441
R13	4	27	Resistor 5.1k \pm 1%	1	26232-390
R14	4	7	Resistor 3k \pm 2%	1	26834-466
R15	4	9	Resistor 4.3k \pm 2%	1	26834-470
R16	4	40	Resistor 9.1k \pm 2%	1	26834-478*
R17	4	18	Resistor 620 Ω \pm 2%	1	26834-450
R18	4	13	Resistor 30 Ω \pm 2%	1	26834-418
R19	4	33	Resistor 10 Ω \pm 1%	1	26232-325*
RV1	4	30	Potentiometer 1k \pm 20%	1	27113-749
RV2	4	12	Potentiometer 4.7k \pm 20%	1	27113-712
C1	4	25	Cap. 1990pF \pm 2% 125V dc)	2	27522-133*
C2	4	25	Cap. 1990pF \pm 2% 125V dc)		
C3	4	26	Cap. 10 μ F 15V dc)	3	27462-405
C4	4	26	Cap. 10 μ F 15V dc)		
C5	4	26	Cap. 10 μ F 15V dc)		
C6	4	5	Cap. 50 μ F 15V dc	1	27462-413*
C7	4	20	Cap. 100 μ F 15V dc	1	27462-417
C8	4	21	Cap. 200 μ F 30V dc	1	27462-421
VT1-VT3	4	8	Transistors 2N 2926	3	28552-601
D1	4	16	Diode 1S921	1	28461-824
D2	4	17	Diode 1Z 12T5	1	28475-281
T1	4	10	Transformer	1	45004
TH1	4	6	Thermistor Type A14 10k \pm 20%	1	27284-330
TH2	4	2	Thermistor Type R14 10k \pm 20%	1	27284-318
-	4	1	Printed Circuit Board	1	3218-328
-	4	3	Heat Sink	1	3565-615
-	4	11	Printed Circuit Tags	6	25255-372*
-	4	34	Printed Circuit Socket	1	45052
-	4	35	Printed Circuit Socket	1	45085

* Additional quantities on Amplifier Board Fig. 3

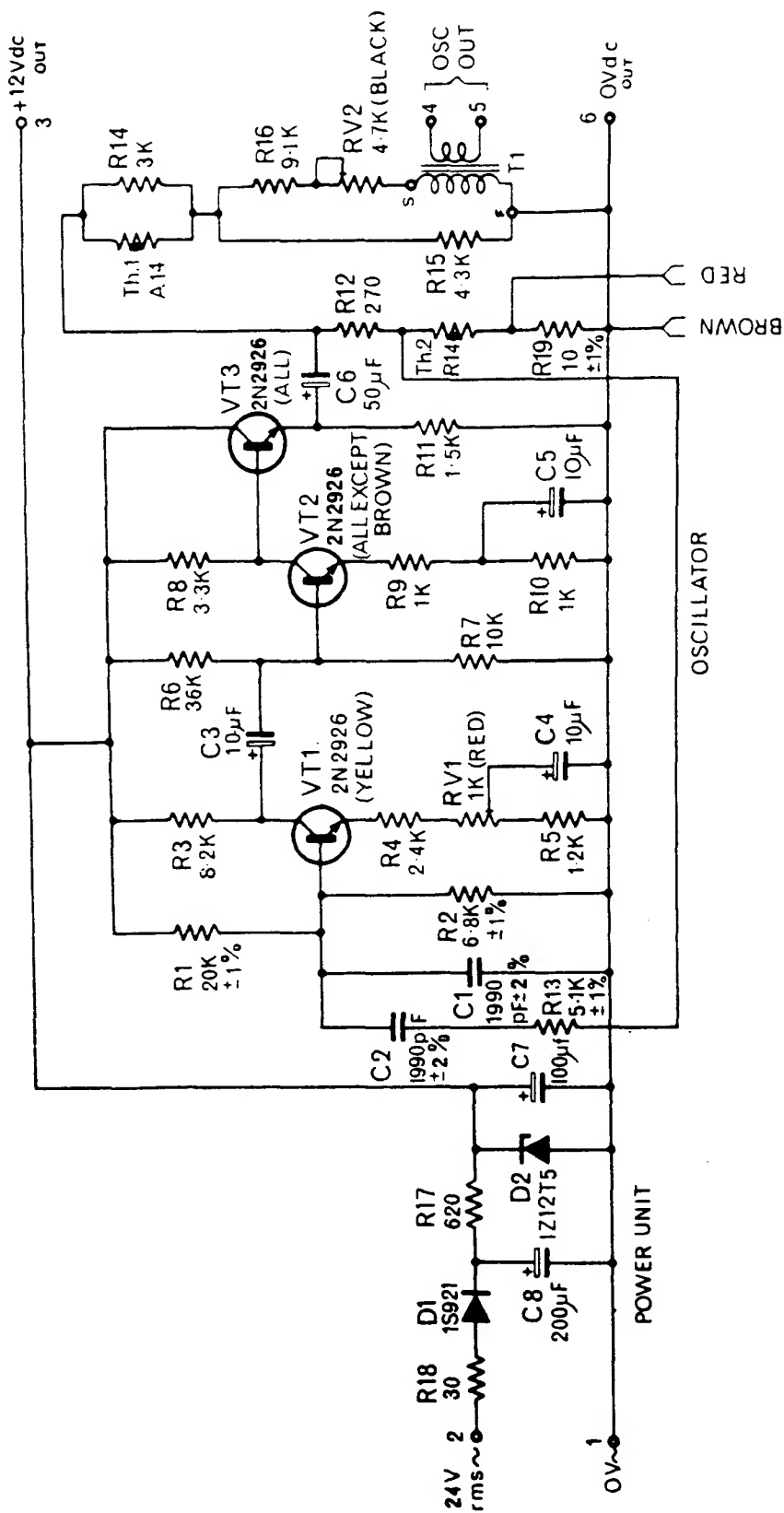


Fig 11. Oscillator and Power Unit Circuit Diagram

FIG. 12 - VCM 163 CIRCUIT DIAGRAM

Circuit Ref.	Assy Fig. No.	Item No.	Description	Qty	AVO Part No.
R1	9	6	Resistor 100k \pm 20%)	2	26136-221
R2	9	6	Resistor 100k \pm 20%)		
R3	9	7	Resistor 700 Ω \pm 2%	1	26782-267
R4	7	2	Resistor 3.4M \pm 1%	1	26232-666
R5	7	11	Resistor 2.27M \pm 1%	1	26236-660
R6	7	10	Resistor 1.3M \pm 1%	1	26232-448
R7	7	9	Resistor 680k \pm 1%	1	26232-441
R8	7	8	Resistor 281k \pm 1%	1	26235-911
R9	7	15	Resistor 91k \pm 1%	1	26232-420
R10	7	7	Resistor 16k \pm 1%	1	26232-402
R11	7	6	Resistor 2.4 Ω \pm 0.05%	1	26434-830
R12	7	5	Resistor 8.02 Ω \pm 1%	1	26437-372
R13	7	4	Resistor 24.3 Ω \pm 1%	1	26441-632
R14	7	3	Resistor 82.8 Ω \pm 1%	1	26444-232
R15	7	12	Resistor 1.1k \pm 1%	1	26233-574
R16	7	13	Resistor 4.3k \pm 1%	1	26232-388
R17	7	14	Resistor 22k \pm 1%	1	26232-405
R18	9	12	Resistor 0.68 Ω \pm 10%	1	26711-253
R19	8	9	Resistor 4.7k \pm 2%	1	26834-471
R20	8	8	Resistor 2.2M \pm 1%)	2	26233-653
R21	8	8	Resistor 2.2M \pm 1%)		
R22	8	5	Resistor 9.7k \pm 1%	1	26338-327
R23	8	2	Resistor 310 Ω \pm 1%	1	26235-736
R24	8	6	Resistor 9k \pm 1%	1	26338-325
R25	8	3	Resistor 1.11k \pm 1%	1	26235-767
R26	8	7	Resistor 7k \pm 1%	1	26338-322
R27	8	4	Resistor 4.29k \pm 1%	1	26235-793
R28	6	1	Resistor 44.4 Ω \pm 1%	1	26235-710
R29	6	2	Resistor 88.9 Ω \pm 1%	1	26235-717
R30	6	3	Resistor 310 Ω \pm 1%	1	26235-736
R31	6	4	Resistor 1.3k \pm 2%	1	26834-458
R32	2	43	Resistor 56k \pm 2%	1	26834-497
R33	2	42	Resistor 2.4k \pm 1%	1	26232-382
R34	9	3	Resistor 1.5 Ω \pm 5%	1	26713-105
R35	6	9	Resistor 2.4k \pm 2%	1	26834-464
RV1	1	-	Potentiometer 500 Ω	1	27133-326
RV2	1	-	Potentiometer 1k	1	27133-331
RV3	1	-	Potentiometer 2k	1	27133-341
RV4	2	26	Potentiometer 10k \pm 1%	1	27238-232
C1-C4	1	-	Capacitors 1 μ F 400V	4	27538-318
C5	9	9	Cap. 8 μ F 450V Electrolytic	1	27461-214
C6	9	11	Cap. 60 μ F 250V	1	27463-560
C7	9	10	Cap. 25 μ F 30V	1	27463-410
C8	6	5	Cap. 0.015 μ F +0-20%	1	27532-393
D1,D2	9	2	Diode DD058	2	28461-501
D3	9	13	Diode 10B1	1	28461-841
D4	1	-	Diode DD058	1	28461-501
D5,D6	1	-	Diode IN 2069	2	28462-696

FIG. 12 - VCM 163 CIRCUIT DIAGRAM (contd.)

Circuit Ref.	Assy Fig. No.	Item No.	Description	Qty	AVO Part No.
S1	2	15	Switch Screen Volts)	2	45803
S2	2	15	Switch Anode Volts)		
S3	2	9	Switch mA	1	45189
S4	2	2	Switch Electrode Selector	1	45828
S5	2	1	Switch Circuit Selector	1	45187
S6	2	21	Switch Leakage	1	45816
S7	2	37	Switch push-button mA/V	1	45431
S8	2	6	Switch mA/V	1	45190
S9	2	38	Switch push-button mA	1	45524
S10	2	12	Switch Grid Volts	1	45188
S11	2	13	Switch Heater Volts	1	45818
S12	2	14	Switch Heater Volts)		
S13	2	14	Switch Heater Volts)	2	45825
S14	2	20	Switch Set Cycles	1	45823
S15	2	22	Switch On/Off	1	25454-251
T1	1	-	H.T. Transformer Assembly	1	45185
T2	1	-	L.T. Transformer Assembly	1	45197
RL1	1	-	Relay	1	45211
LP1	2	25	Indicator Lamp (Blue)	1	25517-235
LP2	2	23	Indicator Lamp (Red)	1	25517-233
M1	2	31	Meter Assembly mA	1	45191
M2	2	30	Meter Assembly mA/V	1	45206
-	2	24	Bulb 6.5V 0.35A	1	25514-679
-	2	28	Front Panel	1	3286-619
-	2	33	Knob Assembly	1	45913
-	2	39	Knob Collet Black	12	23762-235
-	2	40	Knob Cap Grey	12	23762-884
-	2	41	Knob Skirt Black	12	23762-854